CRAWL SPACE VENTILATION SYSTEM

Background of the Invention

This invention is directed to providing ventilation for a crawl space under a house or similar structure, and in particular to provide a fan system for the circulation of ambient air into and from the crawl space to reduce the moisture content of the crawl space air.

The moisture content within a crawl space is the result of having a space between the ground and the floor that is subjected to a moisture buildup from various sources. Some of these sources include leaking pipes, condensation on the exterior surfaces of heating and air conditioning ducts and natural ground water intrusion into the crawl space. Very little opportunity exists for the moisture to be discharged from the crawl space. Openings in the exterior walls are generally small and not properly located to keep the moisture content of the crawl space air from reaching a high percentage. The need exists to provide a positive flow of the air from a source having a lower percentage of moisture into the crawl space and discharging the air within the crawl space having a high percentage of moisture.

The lack of circulation or movement of air within a crawl space results in higher concentrations of radon gas and the inability of the air to carry moisture from the crawl space that has evaporated into the air from

damp surfaces. The harmful effects of radon gas are well known in the building industry and special construction features are used to keep concentrations low, including a ground cover, vent pipes and crawl space vents. In addition. air moving across a moist surface will collect moisture from the surface by evaporation from the surface and transport this excess moisture in the air away from the surface. The better the air circulation the more moisture will be removed from the crawl space by evaporation. This moisture reducing effect is in addition to replacing air having a high percentage of moisture with air having a lower percent moisture as previously discussed.

Some of the bad effects of high moisture content in the crawl space air include wood rot, mold, mildew, fungi, bacteria growth and insect infestation, to mention a few. The crawl space air can have an odor which is also objectionable. Radon gas content of a crawl space having a high moisture content is generally found to be higher than that in a crawl space with a low moisture content. A lower moisture content air of a crawl space has many advantages including, helping prevent termite infestation; helping prevent rusting and corrosion of heating and air conditioning equipment; helping maintain floor insulation "R" factors; and helping prevent high moisture content air from reaching the living space in a home.

Typical crawl space ventilation systems have been disclosed in U.S. Patent Nos. 3,368,756; 4,702,149; 4,829,882; and 4,877,182. The ventilator systems of '756 and '149 are passive systems where the air is not being forced through the crawl space and depends on the natural flow as a result of temperature differences. The ventilation systems of '182 and '882 depend on both intake and exhaust units at the exterior openings and vents of the crawl space. Numerous dehumidification systems are available in the industry to actively remove moisture from a space to reduce the moisture content of the air. These systems are generally used to condition the living area air and are not cost effective for use in conditioning air in a crawl space.

The need remains to have an efficient and cost effective ventilation system for the crawl space under the lower floor of a home or building not built on the ground. The ventilation system should be easy to install as an aftermarket device.

Accordingly, an object of the present invention is to provide a ventilation system for a home or building crawl space which is easily installed and operated but effective in reducing the moisture content of the air within the crawl space.

An additional object of the present invention is to provide air circulation within a crawl space that reduces the concentration of radon gas and

helps reduce the moisture in the crawl space by removing moist air caused by evaporation from damp surfaces.

Another object of the present invention is to provide such a ventilating system which is cost effective to produce, install and operate.

A further object of the present invention is to provide a control system which operates with limited changes and can be set to provide the low moisture content air for the crawl space.

Summary of the Invention

The above objectives are accomplished according to the present invention by a combination of a fan unit suspended from the building floor structure within the crawl space. The fan unit includes a fan, a fan motor an inlet grill and an outlet grill. A timer connected in the power supply activates the fan motor at periodic predetermined time intervals to move the crawl space air through the fan unit. The fan unit is located and orientated to create a negative pressure to pull air into the crawl space through inlet grills and to also create a positive pressure to force air out of the crawl space through outlet grills. Inlet and outlet grills are located in the exterior walls of the crawl space and generally exist in most homes and buildings without adding any new grills. The location and orientation of the fan unit determines which existing grills become inlet grills and which become outlet grills depending on positive and

negative pressures created within the crawl space by the fan unit. The wind direction exterior to the crawl space can also influence which grills are inlet grills and which become outlet grills. However, during certain periods of time, the moisture in the outside air may be too high. An outside humidity sensor can be used to insure the outside air has a lower percent humidity than that desired in the crawl space before the fan motor is activated.

In one embodiment of the present invention a ventilation system is provided for a building crawl space to reduce the moisture content of enclosed air within the crawl space. The system comprises a fan unit having a fan operated by an electrical motor and suspended from the building floor structure and centrally located and orientated within the crawl space. The fan unit includes at least one inlet grill, a discharge plenum and an outlet grill for moving air within the crawl space through the fan unit to establish relatively high and low pressure areas within the crawl space. Inlet vents adjacent to low pressure areas, relative to ambient air pressure, allow for movement of relatively low moisture content outside ambient air into the crawl space. Outlet vents adjacent to high pressure areas, relative to ambient air pressure, allow for movement of relatively high moisture content within the crawl space to the exterior of the crawl space. A timer unit is manually set to transmit a first electrical signal to activate said fan motor for predetermined ventilation time

periods that are set to optimally circulate the crawl space air and reduce the moisture content of the crawl space air.

In one embodiment of the invention the ventilation system includes a controller unit connected to the timer unit having a main switch, a transformer, at least one control logic circuit and the control switch. The transformer reduces the first electrical signal to a low voltage electrical signal.. An outside humidity sensor, activated by the main switch to receive said low voltage signal, determines the percent moisture content of the outside ambient air and transmits a second electrical signal to indicate the outside humidity. The controller unit has a first control logic circuit that receives both the low voltage signal from the transformer and the second electrical signals. The low voltage signal can be transmitted directly to the control switch to turn the fan motor on when the outside humidity is below a first threshold value and to turn the fan motor off when the outside humidity is above the first threshold value.

In a further embodiment of the invention the ventilation system includes an inside crawl space humidity sensor activated by the "yes" low voltage output from the first control logic circuit. The inside sensor determines the percent moisture content of the inside crawl space air and transmit a third electrical signal to indicate the inside crawl space humidity. The controller unit has a second control logic circuit that receives both the low voltage signal from said first logic control circuit and the third electrical signal. The low voltage

signal is transmitted directly to the control switch to turn the fan motor on when the inside crawl space humidity is above a second threshold value and to turn the fan motor off when the inside crawl space humidity is below the second threshold value.

In another embodiment of the invention, a multiple ventilation system for at least one crawl space under a building structure with exterior wall vents is provided to reduce the moisture content of the air within the crawl space. The multiple system comprises a timer unit associated with the at least one crawl space that is manually set to transmit a first electrical signal for ventilation time periods that are determined to optimally reduce the moisture content of the air in a respective crawl space. An outside humidity sensor determines the percent moisture value of the ambient air and generates a second electrical signal to indicate the ambient air moisture value. A first logic circuit is provided to compare the percent moisture value with a predetermined first threshold limit value. A fan unit, having a fan operated by an electrical motor, is suspended from the building structure and centrally located and orientated within the at least one crawl space. The fan unit includes at least one inlet grill, a discharge plenum, an outlet grill and an outlet baffle for moving air within the main crawl space through the fan unit. This establishes relatively high and low pressure areas within a respective crawl space., so that air flows in and out of the respective crawl space through respective exterior wall vents.

A controller unit associated with each crawl space having a main switch, at least one control logic circuit and a control switch receives the first and second electrical signals. The first electrical signal is transmitted to said control switch to activate the fan motor when the outside ambient air humidity is above the first threshold limit value. The first electrical signal turns the fan motor off when the outside ambient air humidity is above the first threshold limit value.

In another aspect of the present invention ventilation of a remote crawl space is realized. The remote ventilation system comprises a duct extending from said discharge plenum of an adjacent fan unit into the remote crawl space. A portion of the discharge air from the adjacent fan unit is diverted and discharged into the remote crawl space to produce an increase in the air pressure within the remote crawl space. The relatively high moisture content air within the remote crawl space is exhausted to the exterior of the remote crawl space through the wall vents.

Description of the Drawings

The construction designed to carry out the invention will hereinafter be described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown and wherein:

Figure 1 is a plan view of typical crawl spaces between a floor structure and the ground surface within walls of a building having a suspended fan unit centrally located in one crawl space to discharge air in one direction to draw outside air into the crawl space through inlet vents and discharge air through outlet vents to provide ventilation for the crawl spaces;

Figure 1A is a plan view of the typical crawl spaces between a floor structure and the ground surface within walls of the building of Fig. 1 having the suspended fan unit again centrally located but reversed to discharge air in an opposite direction and draw outside air into the crawl space through different inlet vents and discharge air through different outlet vents to again provide ventilation for the crawl spaces;

Figure 2 is a perspective view of a fan unit suspended from a typical floor system of the building using flexible straps and including the power supply and controller components for operating the crawl space ventilation system;

Figures 3 is a flow diagram of how the crawl space ventilation components are interconnected and how the controller logic of the controller functions for periodic operation of the fan unit to provide the proper ventilation; and

Figure 4 is a graphic chart of the threshold humidity limits levels in relation to the fan operating time showing the fan operating region allowed when applying inside and outside limits on the humidity .

Description of a Preferred Embodiment

Referring now in more detail to the drawings, the invention will now be described in more detail. A fan unit 20 is suspended from the building floor structure 7 by flexible straps 30 within a crawl space 10 at a somewhat central location within the crawl space area, as illustrated in Figs. 1 and 2. The fan unit includes a fan motor 22, inlet grills 24, a discharge plenum 25, and an outlet grill 26. A timer unit 41 connected to a controller 40 activates a fan motor 22 at periodic predetermined time intervals to move the crawl space air through the fan unit. The fan unit is located and orientated to pull air into the crawl space through inlet vents 12 and force air out of the crawl space through outlet vents 14. Inlet and outlet vents or grills are located in exterior walls 18 of crawl space 10 and generally exist in most homes and buildings and usually include a grill and hinged cover for closing the vent when ventilation of the crawl space is not wanted or needed. These vents normally exist in buildings to obtain natural or free ventilation of the crawl space. The location and orientation of fan unit 20 determines which existing vents become inlet vents and which become outlet vents; depending on negative pressure locations 10a created within the crawl space adjacent inlet vents and positive pressure locations 10b created within the crawl space adjacent outlet vents. The wind direction exterior to the crawl space can also influence which vents are inlet vents and which become outlet

vents. The plan view of Fig. 1A shows fan unit 20 discharging air in an opposite direction to that shown in Fig. 1. In this case the location on inle vents 12 and outlet vents 14 has changed. The essential operation is to draw an equal quantity of air into the crawl space as there is being discharged from the crawl space. According to the present invention it is not important which vents become inlet vents and which become outlet vents as long as a flow of air is maintained to achieve more changes of air in the crawl space per unit of time compared with the crawl space having no fan unit. The serpentine arrows of Figs. 1 and 1A illustrate a possible direction of the flow of air within the crawl space.

A remote crawl space area 11 may exist which is separated from the main crawl space 10. For these remote areas a duct 28 is provided as illustrated in Figs. 1 and 1A. The duct connects to discharge plenum 25 with vanes in the discharge plenum to direct air into the duct. Air is discharged into the remote are from an end 29 of the duct and increases the pressure in the remote area. This higher than ambient pressure moves the air in the remote area out through outlet vents 15 to the outside. Additional remote areas can be ventilated in the same way.

The overall objective is to reduce the moisture content of the crawl space air by moving the air within the crawl space and replacing the air within the crawl space. Therefore, it is necessary to pull air into the crawl

space that has a lower moisture content than the air within the crawl space without ventilation. One aspect of the crawl space ventilation system of this invention depends on the outside ambient air having a lower moisture content. An outside humidity sensor 60 is included to monitor the percent moisture of the outside ambient air. If the outside ambient air has a higher moisture content than the inside crawl space air, little or no advantage is achieved by bringing outside air into the crawl space. In addition, an inside humidity sensor 64 is included to monitor the percent moisture in the crawl space air. If the crawl space air already has a low moisture content, the crawl space moisture is under control and there is also little or no advantage in bringing outside air into the crawl space. However, the movement of air for evaporation of moisture from damp surfaces and the lowering of radon gas concentrations may continue to yield positive results, regardless of the inside or outside humidity. The ventilation system of this invention has the option of using or not using the inside and outside air humidity values to operate the fan unit. The humidity sensors are those commonly found in the building industry to measure percent moisture and transmit a proportional electrical signal.

A detailed view of the working components of the ventilation system for a building crawl space is illustrated in Fig. 2. Fan unit 20 is suspended within the crawl space below the building floor 5 from floor

structural members 7 using flexible straps 30. The straps are attached at the top to the floor members using fasteners 30a and at the bottom to the fan unit by fasteners 30b. This suspension means allows the fan unit to operate without structural vibrations and noise.

The fan unit has an inlet grill 24 on at least one side to pull air into the fan unit from the crawl space and an outlet grill 26 for discharging air from a discharge plenum 25 back into the crawl space, as indicated by the arrows in Fig. 2. An outlet baffle 27 associated with the outlet grill of the fan unit provides back pressure in the discharge plenum so that the fan unit operates at a desired speed and power rating. A power cable 52 is brought from the building electrical power system to the fan unit. The power cable is first terminated in a power receptacle 50, located near the fan unit, to be further extended to a timer device 41 through a system cable 54. When the timer device is requesting the fan unit be turned on, electrical power is transmitted through a timer conduit 42 to a controller unit 40. The controller unit contains logic components to decide if further conditions are satisfied to allow the fan unit to be operated. A previously discussed, these conditions may include the existing percent moisture in the crawl space as well as the percent moisture in the outside ambient air. For convenience, the power receptacle, the timer device and the controller unit can be located near the fan unit.

To determine the conditions of the outside ambient air, exterior humidity sensor 60 is monitored. A low voltage signal is transmitted to the outside humidity sensor through sensor cable 62 and a signal is returned through the same cable to indicate the percent moisture of the outside ambient air measured by the outside humidity sensor. To determine the conditions of the inside crawl space air, interior humidity sensor 64 is monitored. A low voltage signal is transmitted to the inside humidity sensor through sensor cable 66 and a signal is returned through the same cable 66 to indicate the percent moisture of the inside crawl space air measured by the inside humidity sensor. The logic used to operate the fan unit when considering humidity values (percent moisture) in the present ventilation system will be discussed later.

If the decision from the controller is to operate the fan unit, electrical power is allowed to flow from controller 40 through fan cable 44 to a fan connector box 23. Power is further transmitted to the electrical fan motor 22 through the motor conduit 21 to ventilate the crawl space.

A flow diagram of the crawl space ventilation system is shown in Fig.3. The building electrical power is transmitted through power cable 52 to power receptacle 50 located near the fan unit. System cable 54 transmits power directly to timer device 41. Operating parameters are set within the timer device using the timer dial 41a to adjust how often the fan should be

turned on and the amount of time to operate the fan unit each operating interval. A nominal operating time may be to turn on the fan unit each hour for about 15 minutes. Depending on the layout of the crawl space and the moisture conditions within the crawl space the timer device can be set to operate more or less than the nominal conditions. Each installation will need to be evaluated as to what is optimum; depending on the amount of air circulation achieved by the fan unit, the amount of excess moisture normally present within the crawl space and the building location and nominal outside environmental conditions, including wind direction and average velocity. Test installations have indicated that little change is needed once the general layout of the crawl space, existing moisture problems and the location of the building are all accounted for.

If the timer device is indicating the fan unit should be turned on, power is transmitted to controller unit 40 through timer conduit 42 to the control switch "S". The switch is used to select whether humidity conditions will be used or not to operate the fan unit. With the switch in a first position, the humidity sensors are bypassed and power is transmitted directly through cable 42a from control switch S to turn on the control switch. Power is further transmitted through fan cable 44 to fan connector box 23 and fan motor 22 through motor conduit 21 to turn on the fan unit. If the switch is in a second position, the outside humidity and the inside humidity will be

monitored to determine if existing moisture conditions outside and inside the crawl space are within limits for optimum operation of the fan unit. Electrical power is transmitted through timer cable 42b to control switch 40d which can be turned on or off by the logic circuits of the controller. The humidity monitoring circuits use low voltage sensors and components to transmit signals to and from sensors 60 and 64. Power is transmitted directly to a transformer 40a to produce the low voltage electrical power for the humidity monitoring circuits.

If the outside humidity is too high the advantages of drawing outside air into the crawl space are diminished. In addition, if the humidity inside the crawl space is already low at a particular time it may not be economical to ventilate the crawl space at that time. The humidity monitoring circuit allows these two conditions to be checked and the crawl space ventilation system to be turned off during the time it would normally be operating.

Outside humidity sensor 60 receives low voltage power through sensor cable 62 and transmits back to the controller a percent moisture signal for the outside air. The control logic circuit 40b of the controller compares the outside humidity with a predetermined high threshold humidity value acceptable for continuing to ventilate the crawl space. If the humidity of the outside air is below this high value then the fan unit can be operated,

but if the outside air is above this high value, control logic circuit 40b tells control switch 40d to terminate any power from being transmitted beyond the control switch. For example, if it is raining outside, it would not be helpful to bring this 100 percent moisture content air into the crawl space. The high threshold value can be set by either a dial on the controller or a sensor dial 60a on the humidity sensor.

Inside humidity sensor 64 receives low voltage power from sensor cable 66 and transmits back to the controller a percent moisture signal for the air inside the crawl space. The control logic circuit 40c of the controller compares the inside humidity with a predetermined low threshold humidity value acceptable for continuing to ventilate the crawl space. If the humidity of the air inside the crawl space is above this low value then the fan unit will be operated, but if the moisture content of the crawl space air is below this low value the control logic circuit 40c tells control switch 40d to terminate any power from being transmitted beyond the control switch. For example, if it is a time of very low humidity, say 20 percent, or the crawl space ventilation system has been working well, it may not be economical to bring this 20 percent moisture content air in the crawl space any lower. The system can actually bypass some operating cycles when it would normally be ventilating the crawl space. If both the outside air has a moisture content below a high value and the inside air has a moisture content above a low

value, the control switch 40d is turned on and power is again delivered to fan motor 22 and the crawl space is ventilated.

Operation of the system with humidity sensors 60 and 64 limiting on-time for the fan unit is illustrated in the graph of Fig. 4. During the time for ventilation set by the timer device, when the fan motor is to be turned on and before it is to be turned off, the fan unit is normally operating to ventilate the crawl space. However, if switch S of the controller is in a position to consider existing humidity conditions, the fan unit may be turned off. With an acceptable outside threshold limit on the humidity of the ambient air established and set by sensor dial 60a, the fan unit only operates when the outside humidity is below this value. With an acceptable inside threshold limit on the humidity of the crawl space air established and set by sensor dial 64a, the fan unit only operates when the crawl space humidity is above this value. These two limiting conditions defines a fan operating region, as illustrated in the graph of Fig. 4. When conditions exist within this operating region the crawl space will be ventilated.

It is possible to operate the ventilating system with only outside ambient air humidity being a factor by simply setting the inside threshold limit to zero. The ventilating system will then operate considering the timer device and ambient air humidity conditions only. In a similar mode, it is possible to operate the ventilating system with only inside crawl space air

humidity being a factor by simply setting the outside threshold limit to 100 percent. The ventilating system will then operate considering the timer device and crawl space air humidity conditions only.

Once again, there are other considerations beside the air moisture content to consider. The advantages of circulating air within the crawl space are important in removing radon gas concentrations and in removing moisture from damp surfaces that may rust of otherwise be damaged by moisture. The recommended method for radon gas is to provide a ground cover of polyethylene sheeting with a plumbing tee beneath the sheeting having a vent pipe through the sheeting and up through the roof. The vent pipe would not need to be extended through the roof with the present ventilating system as the air is being removed from the crawl space.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.